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DELINEATION OF GROUNDWATER POTENTIAL SITES IN SITAMOU AREA, SHIVNA RIVER BASIN, MANDSOUR DISTRICT, MADHYA PRADESH, INDIA

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ABSTRACT

The delineation of groundwater potential sites based on morphometric analysis of the Shivna River Basin of Sitamou area located in Mandsour district of Madhya Pradesh, India, has been conducted. The morphometric analysis of a part of Shivna River drainage basin covering an area of 118.15 km^2 in Sitamou block has been conducted based on Survey of India toposheet No 45 P on 1: 50,000 scale. The drainage basin is divided into three A, B, and C sub-basins. The results of linear, areal and relief parameters specify a fairly good variation range and their significance has been discussed. The hypsometric analysis of Shivna River basin around Sitamou reveals that the sub basin C belongs to Young stage and sub basins A and B represent Mature stage of River drainage development. The inter- relationship between morphometric parameters such as number of streams and stream order and length of stream and stream orders have been illustrated. An attempt has been made using geomorphic evidence to delineate the groundwater potential sites within the vicinity of Shivna River Basin, Sitamou area**.**

KEYWORDS: Delineation of Groundwater, Shivna River Basin, Sitamou Area

INTRODUCTION

This paper deals with the application of geomorphologic analysis of a part of Shivna River, Sitamou area, located in Mandsour district of Madhya Pradesh, within latitudes 24^0 2`: 24$^0$ 17`N and longitudes 75^0 10` : 75$^0$ 25` E (Survey of India toposheet no. 45 P, Figure 1), for the identification of favourable groundwater potential sites for exploitation. The study area is more or less flat with a few hillocks and is mainly drained by Shivna River and minute seasonal streams. The climate is dry expect in the south-west monsoon season. The post monsoon period is characterized by a pleasant climate. Temperature rises rapidly form March to May with a maximum of 45^0 C and minimum of 10.4^0 C. Most of the rainfall is witnessed during monsoon season. Annual rainfall ranges from 402.3 mm. to 1394.2 mm with an average of 849.39 mm. The humidity ranges from < 25 % to > 70 %.and winds are generally light and variable in direction, except during the later period of summer.

Geology and Geomorphology

Geologically, Sitamou area constitutes a part of the Deccan Trap Volcanic Province, which is extending from the Bombay, Kathiawar, Kutch, and Madhya Pradesh, Central India (covering an area of 5, 10, 000 sq. km). The Geological Survey of India has prepared the geological and tectonic maps of the area. The study area is occupied by the middle lava flow of Deccan Traps (locally known as Malwa Trap).Two lava flows of massive, and vesicular basalt have been observed. Most of the area is covered by the lava plains (Figure 2).

Geomorphology is a science and art that mainly concerns with the study of landforms and surface processes. Landforms are resulted due to both erosional and depositional relief features of earth. The description of landforms based on genesis was first published by Davis (1909). and Russel (1949) recognized different stages in the development of

landforms, Sparks (1960) described the application of morphometric analysis. Geomorphologically, the study area exhibits survival of both the ersosional and depositional landforms, which include hill, lava plain, valley, and soils. and is mainly drained by the Shivna River with tributaries .

Material and Methods

The primary material used for morphometric analysis of Sitamou area includes the Survey of India toposheet no. 45 P on the scale of 1: 50,000. A drainage map of study area has been prepared based on toposheet (Figure 3) and followed by the field verification of identified earth's features. Morphometric parameters namely areal, linear and relief aspects of the study drainage basin have been determined by adopting Horton's (1945) system, Strahler (1952 a) and other workers, have been followed and the values of various parameters are displayed (Table 1).

Morphometric parameter of sub-basins of the Sitamou drainage basin have been computed based on different morphometric variables by using standard formula propsed by several workers. Hypsometric analysis has been conducted by using method of Strahler (1952 b). The inter relationship of morphometric parameters namely the number of streams and stream order, and length of stream and stream orders have been determined and illustrated.

Morphometric Analysis of Drainage Basin

The computed linear, areal and relief parameters of Sitamou drainage basin have been described.

- **Stream Pattern:** The system of ordering streams of any river has been given by several workers, including Horton (1945) and Strahler (1952) have been adopted. The first order streams are those, which have no tributaries. When two first order streams meet, form the second order stream. In the same manner, the third order stream is formed by joining of two second order streams, the river and streams of study area have been numbered in the same manner (Figure 3, Table 1).

- **Bifurcation Ratio:** is one of the important characteristics of drainage basin. Horton (1932) defined the term as "the ratio between the numbers of channel seqments of the next higher order (Nu +1)". Bifurcation Ratio is represented by symbol 'Rb' and usually expression as: Rb = Nu / Nu + 1, where, Rb = Bifurcation ratio, Nu = Number of channel segment of particular order and Nu+1 = Number of channel segment of Next higher order. Determinations of bifurcation ratio of the study drainage sub-basins have been calculated. Bifurcation Ratio in Sitamou area varies from 1 to 2.66 with an average value of 1.96 (Table 2).

- **Drainage Density:** is expressed by symbol "Dd", which is a ratio between the cumulative length of channel segments of all orders within a basin to the basin area. Drainage Density is represented by following formula - Dd = L / A**, w**here, Dd = Drainage density, L = Sum of total length of stream of all order, A = Total drainage basin area in sq. km. It has been observed that the drainage density ranges from 0.884 to 1.078. with an average value of 0.9923 (Table 2).

- **Length of Overland Flow:** is one of the most important variables that effect hydrologic development of a drainage basin. It is determined by formula: Lo = 1 / 2 Dd. where, Lo = Length of overland flow, Dd = Drainage density. Horton (1943) and Schumm (1956) remarked that the length of overland flow is approximately equal to the half of drainage density. The length of overland flow varies from 0.463 to 0.492 with an average 0.5067 in study basin.

- **Stream Frequency:** has been denoted as the ratio of total number of channels of all orders in a basin to the area

of the entire basin. It is represented by formula: Sf = N / A, where, Sf = Stream frequency, N = Sum of all stream basins, A = Total area of drainage in Km^2. The stream frequency of study area ranges from 1.09 to 2.450 with an average of 1.646.

- **Circularity Ratio:** has been defined as 'the ratio of area of basin of circle with same perimeter' (Miller 1953). It is expressed by the symbol 'Rc' and is determined by equation: $Rc = 4 \pi A/P^2$, where, Rc = Circularity Ratio. It is study area ranges from 0.616 to 1.710 with an average value of 1.174.

- **Elongation Ratio:** or Elongation has been expressed by Schumm (1956) as "the ratio between the diameter of the circle with same area as basin and basin length" This ratio is expressed by symbol 'Re' or E. as $E = 2 / L /\sqrt{A/\pi}$, where, E = Elongation Ratio, A =Area of basin , L = Length of basin. In study area elongation ratio varies from 0.71 to 2.24 with an average of 1.36.

- **Form Factor:** deals with the shape of basin and is determined by the following expression: $F = A / L^2$, where, F = Form Factor, A = Drainage area of drainage basin, L = Basin Length. Form factor varies from 0.4 to 1.026 with an average value of 1.867.

- **Lemniscates:** is expressed by the symbol 'K'. It is generally determined by following formula: $K = L^2 / 4A$, where, K = Lemniscates, A = Basin Length, A = Basin area. Lemniscates noted as ranging from 0.243 to 0.625 for the study drainage basin.

- **Basin Relief:** has been defined by Strahler (1952) as 'the difference between the highest and lowest point in the basin'. Schumm (1956), considered that basin relief is 'the measure of the longest dimension of the basin parallel to the principal drainage line'. It is expressed by the symbol 'H' or 'Hb'. In the study area, the highest elevation point is observed as 1536 m. a.m.s.l and the lowest elevation point is of 1325 m a.m.s.l. H = Highest point of basin – Lowest point of basin, H = 536 –1325, H = 211 m, In the study area, Basin relief is determined as 211 m.

- **Ruggedness Number:** has been defined as: 'the product of the relative relief and drainage density.It is expressed by symbol 'Hd'. Strahler (1958) considered that Ruggedness Number is the product of maximum Basin Relief and Drainage density. Hd = H X Dd, where, Hd = Ruggedness number, H = Maximum Basin Relief, Dd = Drainage density. The values of H and Dd have been determined as 211 m and 0.9923 m. respectively and determine Ruggedness number as: Hd = 211 X 0.9923 = 209.37, Hence, Ruggedness Number for study drainage basin is 209.37.

Hypsometric Analysis

The percentage hypsometric curve is a plot of the continuous function relative height 'y' to relative area 'x'. The relative height 'y' is the ratio of height of a given contour 'h' to total basin height 'H'. The relative area 'x' is the ratio of horizontal cross sectional area a to entire basin area 'A' (Figure 4), shape of the hypsometric curve varies in early geologic stage of development of the drainage basin, but once a steady state is attained (mature stage), tends to very little, despite lowering relief. Isolated bodies of resistant rock may form prominent hills (monadnock) rising above a generally subdued surface, it forms a distorted hypsometric curve, known as monadnock phase. The hypsometric analysis of study sub-basins exhibits that sub basins C belong to the young stage, whereas the sub-basin A and B fall in mature stage.

RESULTS AND DISCUSSIONS

The results of morphometeric analysis of the Sitamou drainage basin indicate streams of three orders, which

decrease in number as the order increases. Bifurcation Ratio ranges from 1 to 2.66 with a mean value of 1.96, suggesting lithological control over drainage basin. The impacts of geological structures are rather insignificant. Drainage density range from 0.884/km to 1.078/km with a average of 0.9923/km reflecting rather a flat drainage basin. The length of overland flow varies from 0.463 km to 0.565 km with a mean as 0.5066 km, indicating that the water covers a less distance before emerging into the drainage channel. The stream frequency of the present area indicates a moderate development of streams. Elongation Ratio in the Sub-Basin A, B, C, range within 0.71 and 2.24 reflecting that the area is characterized by low relief. Circulatory ratio reveals variation range from 0.616 to 1.710 suggesting a more or less circulatory nature of basin. The Lemniscate indicates a variation from 0.243 to 0.625 for the study drainage basin. The form factor varies from 0.4 to 1.026 with an average value of 1.867. Basin relief is determined as 211m and it is considered as fairly low. Ruggedness number value of 0.85 indicates the development of rather uneven topography.

The plots of number of streams and stream order reveal that except sub-basin B, the number of streams decreases with the increase of stream order (Figure 5). The relationship between stream length and stream order exhibits that with the increase of stream order the stream length decreases (Figure 6). Geomorphologic features and observations provide valuable clues that ave indicated locations of favourable groundwater potential zones in the drainage basin. The drainage basin reveals dendritic to sub-dendritic drainage pattern indicating groundwater potential sites

CONCLUSIONS

The morphometric analysis of Shivna River drainage basin in Sitamou study area, provides significant data on characteristics of the linear, areal and relief parameters. It is drained by streams of 1st to 3rd orders, and the maximum 40 streams are observed in sub-basin B and C , whereas the minimum number of 29 streams is noted in sub-basin A . It has been observed that with the increase of order of streams, the number and length of streams reveal a decreasing trend.

The interpretation of morphological parameters indicates that the Sitamou drainage basin is characterise of by presence of hard rocks having a rather elongated, high value of stream frequency, more or less circular favourable for water infiltration, sub-basins having low relief ratio point out the existence of flat basin with low intensity of erosion, the sub-basin indicating high relief with high intensity of the erosion process and undulated topography. Hypsometric analysis exhibits river developmental stages from young stage (sub-basin C) to mature stage (sub-basin A and B). Based on results of geomorphological analysis,identified the favourable groundwater potential zones in vicinities of Hingoria, Nahargarh, Napakhera, Payakheri, and Tidwas.

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APPENDICES

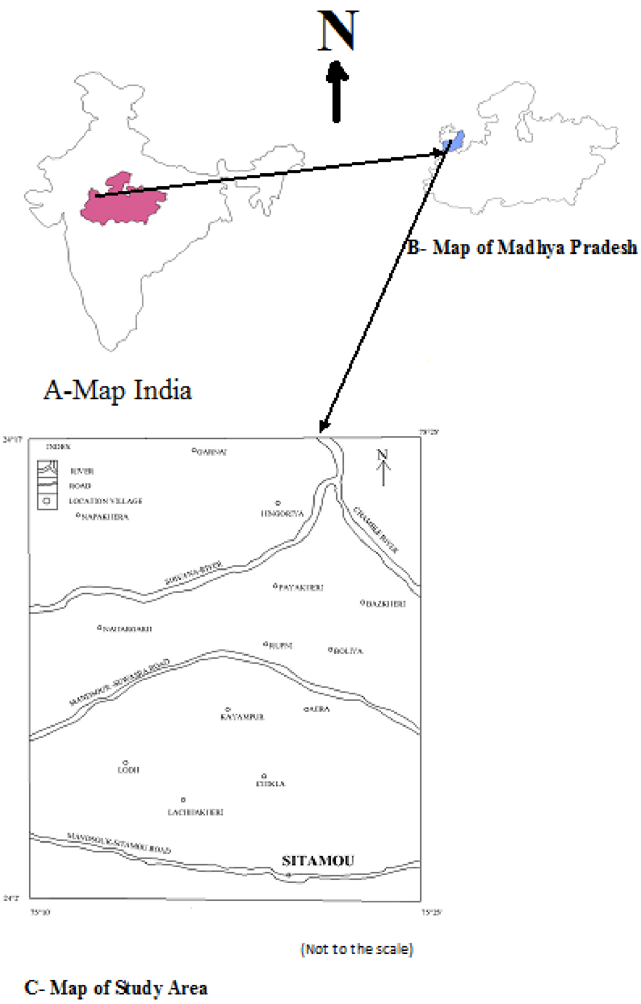

Figure 1: Location Map of Sitamou Area Mandsour District Madhya Pradesh, India

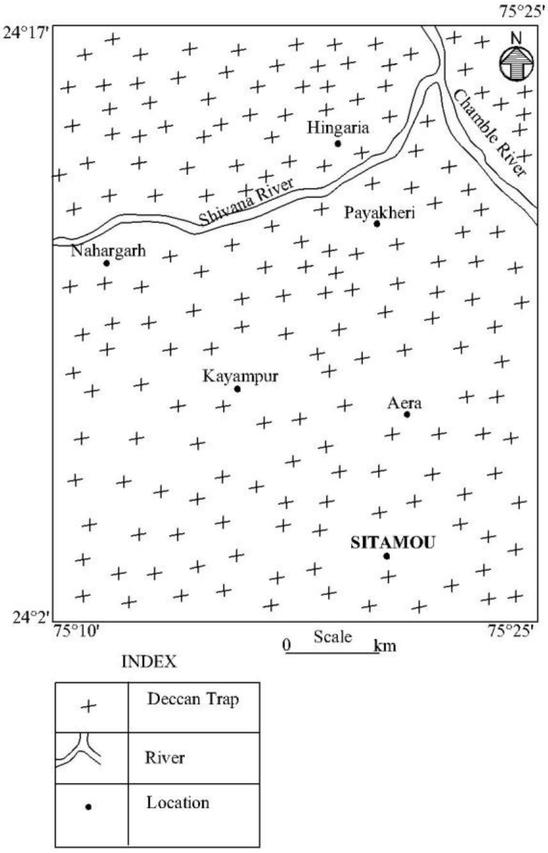

Figure 2: Geological Map of the Sitamou Area, Mandsour District, Madhya Pradesh

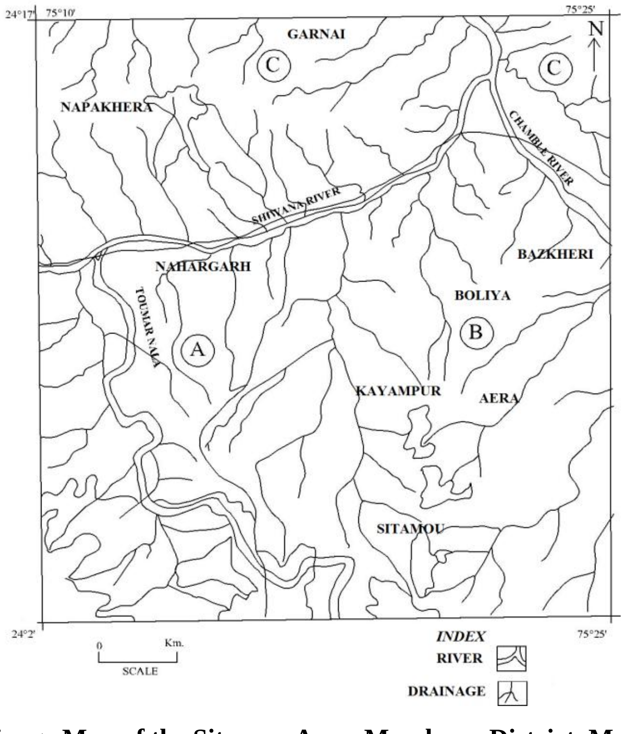

Figure 3: Drainage Map of the Sitamou Area, Mandsour District, Madhya Pradesh

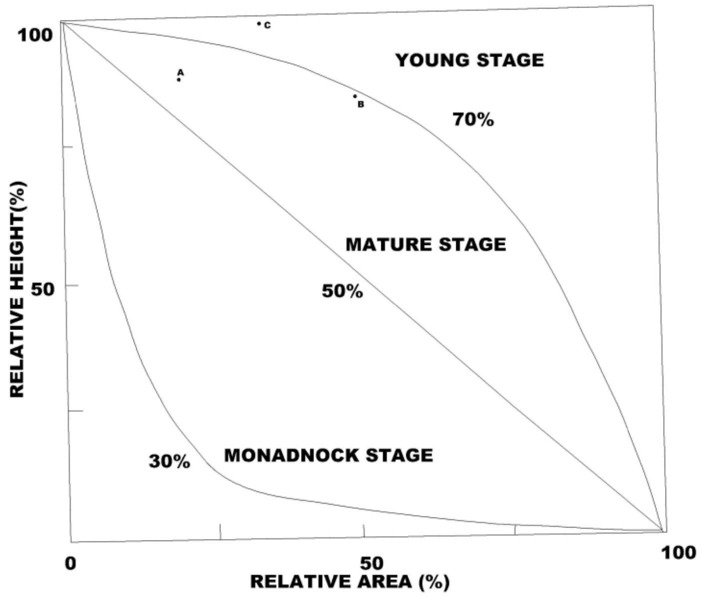

Figure 4: Percentage Hypsometric Curve for the Determination of Stages of River Basin Development

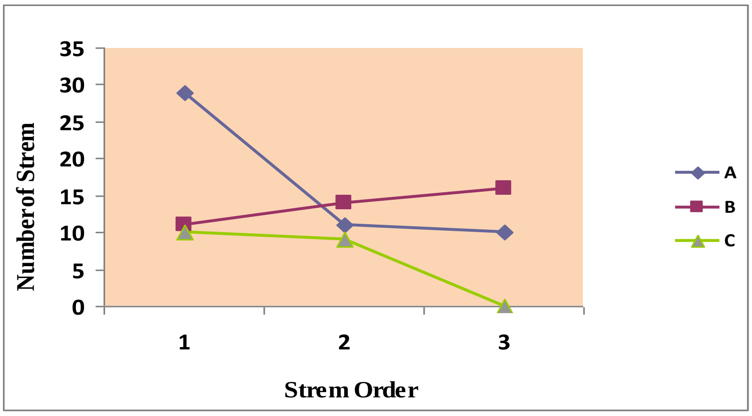

Figure 5: Relationship between Number of Stream and Stream Order

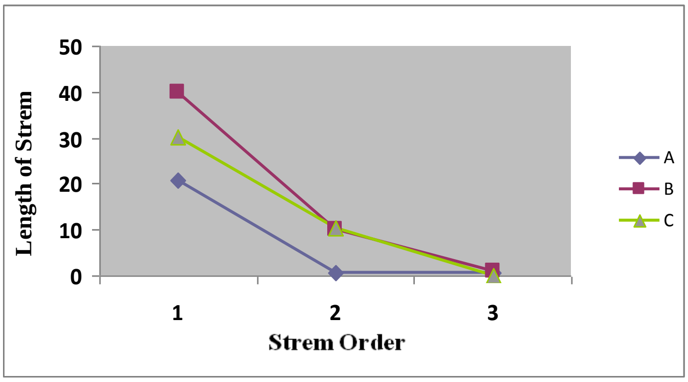

Figure 6: Relationship between Length of Stream and Stream Order

Table 1: Showing details of Geomorphic Variables of Sub Basin of the Shivana River Basin, Sitamou Area, Mandsour District, Madhya Pradesh India

S No	Morphometric Variables /Parameters	Shivna River Basin of Sitamou Area, Mandsour District, M. P. India		
		Sub-Basin A	Sub-Basin B	Sub-Basin C
1	Number of first order stream	29	40	40
2	Number of second order stream	11	14	16
3	Number of Third order stream	10	9	0

Table 1: Contd.,

4	***Total Number of stream***	***50***	***63***	***56***
5	Length of first order stream (Km.)	20.9	40.01	30.3
6	Length of second order stream (Km.)	0.5	10.1	10.3
7	Length of Third order stream (Km.)	0.6	0.9	0
8	***Total Length of stream (Km.)***	***22***	***51.1***	***40.6***
9	Basin Perimeter (Km.)	20.4	20.6	20.5
10	Length of Basin (Km.)	6.8	7.5	10
11	Width of Basin (Km.)	3	7.7	4
12	Area of Basin (Km.)	20.4	57.75	40
13	Highest Elevation	1533	1536	1488
14	Lowest Elevation	1375	1327	1479

Table 2: Determination of Morphometric Parameters of Sitamou Drainage Basin, Mandsour District

S No.	Morphometric Parameters	Shivna River Basin of Sitamou Area, Mandsour District, M. P,			
		Sub-Basin A	Sub-Basin B	Sub-Basin C	Average/ Remark
1	Bifurcation Ratio	2.41	2.66	2.35	1.96
		1	1.4		
		-	-		
2	Drainage Density	1.078	0.884	1.015	0.9923
3	Elongation Ratio	2.24	1.14	0.71	1.36
4	Circulatory Ratio	0.616	1.71	1.19	1.17
5	Stream Frequency	2.45	1.09	1.4	1.64
6	Form Factor	0.44	1.02	0.4	1.86
7	Lemniscate Ratio	0.56	0.24	0.62	0.47
8	Length of Overland Flow	0.46	0.56	0.49	0.5
9	Channel Maintenance	0.92	1.13	0.98	1.01
10	Basin Relief	158	211	9	126
11	Relief Ratio	23.23	28.13	0.9	17.42
12	Ruggedness Number	170.32	186.52	9.13	121.99

Table 3: Computation of Variables for Hypsometric Analysis of Study Area, Mandsour

Sub-Basin	Highest Elevation H (m)	Lowest Elevation h (m)	Y=h/H	Basin Area (a)	Total Area (A)	X=a/A
A	1533	1375	89.69	20.4	118.15	17.26
B	1536	1327	86.39	57.75	118.15	48.87
C	1488	1479	99.39	40	118.15	33.85